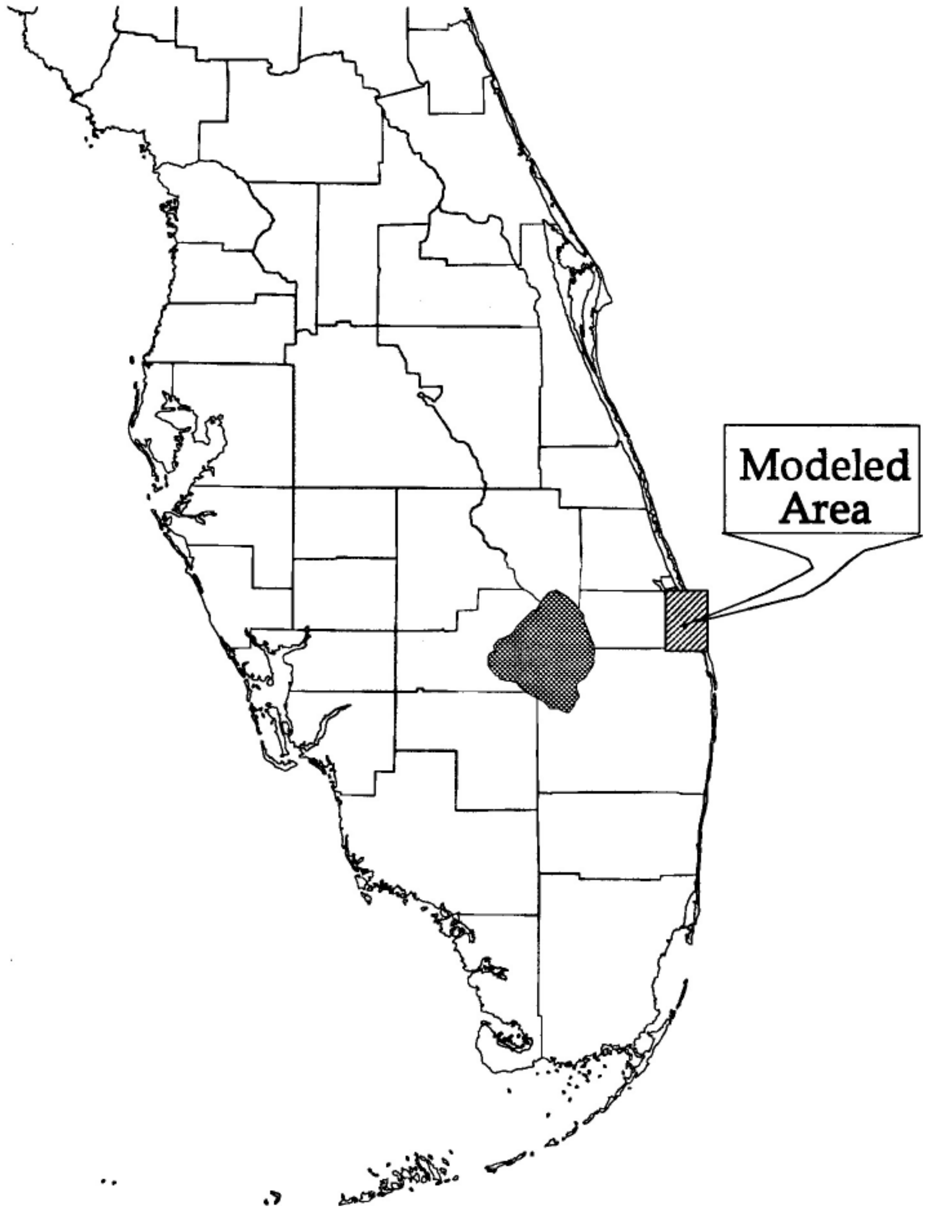
Martin Coastal Subregional Model Documentation



Introduction

The Martin Coastal Area Subregional Model was derived from the Martin County Surficial Model **(Adams, 1992).** The model encompasses coastal Martin County, from the St. Lucie Estuary south to the Jupiter Inlet, and as far west as the South Fork of the St Lucie River. It is discretized into 500 foot-square cells, with 16 cells representing each one in the regional model (Figure 1).

During preliminary work for the Upper East Coast Water Supply Plan, output from the regional model projected great potential for impacts to wetlands in coastal Martin County due to drawdowns from water use withdrawals. It was hypothesized that some of these projected impacts might be erroneous, artifacts of the scale of the model. The subregional model described herein was constructed for the purpose of testing this hypothesis. (Note: it is expected that the model will find regulatory application as well, once the water supply plan is completed) After initial construction, predicted heads from the subregional model were compared to both observed water-levels and those predicted by the regional model for the calibration period (1/89 - 12/90). The objective was to produce a large scale model of the area of concern which would function at least as well, or better than its progenitor with minimum alteration. The two models share many things in common. It is the intent of this report to document how they differ.

Summary of Differences

Boundaries: The Martin Coastal model, like the Martin regional model, is surrounded on all sides by a general head boundary. The general head values for the subregional model were extracted from the output of the regional model, while the regional model boundaries were based on interpolation between observed water levels. Starting heads also came from the regional model calibration.

Hydraulic Properties of the Aquifer: With the exception of producing zone transmissivity, all hydraulic properties are interpolated directly from the regional model. The producing zone transmissivity was modified to include information from pumping tests unavailable during the regional model calibration. These included transmissivity estimates from Roschman Enterprises and Intercoastal Utilities **(Lukasiewicz & Adams, 1996).**

Wells: Three classes of demand are incorporated into the models well packages: public water supply, residential self-supply, and irrigation. The public water supply and residential self-supply components are derived directly from data collected for the regional model calibration. Irrigation well demands were estimated based on irrigated acreage information from the 1990 water use permit database. The modified Blaney-Criddle equation was used to estimate monthly supplemental crop requirements for each permit based on observed rainfall for the 1989 - 1990 period, and that demand was distributed across the permitted withdrawal facilities.

Recharge: Initial estimates of groundwater recharge to thMartin Coastal model were made in the same manner described in the regional model documentation. During calibration of the regional model, Adams (1992) found that this methodology delivered excessive recharge in the high dune soils of the coastal ridge, and applied a reduction factor in those areas based on the thickness of the unsaturated zone. A similar problem was noted during calibration of the subregional model, and a variation of Adams reduction factor was applied (Figure 2). The recharge factor was derived through a multi-step process. Areas of sandy, high-slope soils were identified from the county soils coverage. Where land-surface elevation exceeded 20 feet, recharge was multiplied by a factor of 0.3, otherwise recharge on these soils was reduced by a factor of 0.5. In addition, in areas with a high density of impervious surface (identified from satellite ima)gery, recharge was further reduced. The multiplier accounts for areas where significant unsaturated zone storage would reduce the direct recharge to the water table, and local recharge would be strongly impeded by impervious surfaces. The recharge multiplier is

Model Scale
Regional vs. Sub-regional

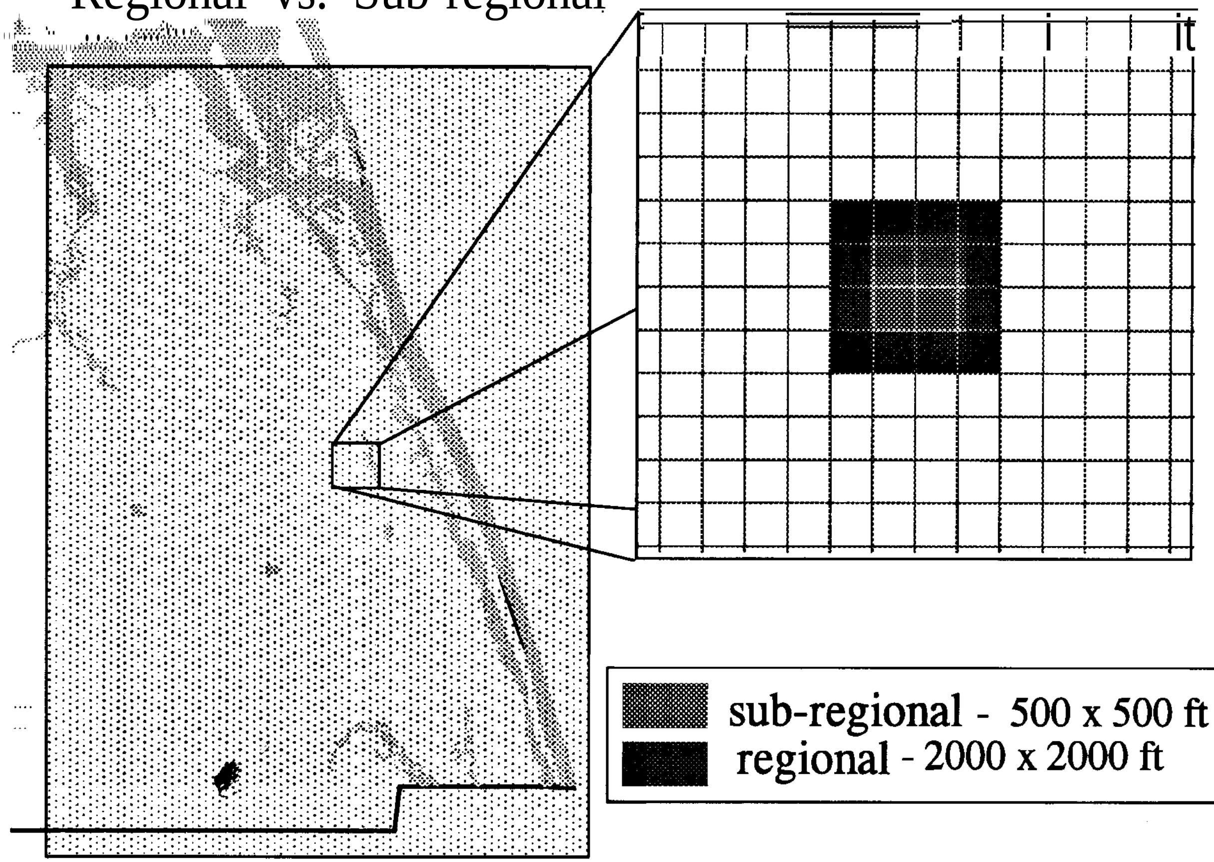


Figure 1

essentially a calibration parameter. As more comprehensive methods of estimating recharge are developed, the need for it will be eliminated.

Evapotranspiration (ET):

surface - The ET surface in the subregional model is significantly different from that found in the regional model. This is to be expected since the regional model reflects the average land-surface over 16 times the area of the subregional model. The new ET surface was created using digitized quad-sheet contours and point elevation data from the United States Geological Survey (USGS). The actual surface was created in Arc/Info using the *topogrid* command, a new feature of Version 7 designed specifically for topography. In addition to this, imagery from the SPOT satellite and soils data were used as basis for local modification to the ET surface on the high-ridge in Jonathan Dickinson State park.

extinction depth - ET extinction depths were derived from landcover using the same methodology applied in the regional model. Differences are a function of scale due to the altered ratio of different landcovers within a model cell, and local modifications for the purpose of improving calibration.

rate- The maximum ET rate is identical to that used in the regional model.

Rivers & Drains: Any feature represented by the river package in the regional model is similarly designated within the Martin Coastal model. All of the regional model drains are represented as well, but with some additions. Because the sub-regional model operates on a finer scale, it is more heavily influenced by local

drainage features. For this reason, small lakes and excavated wetlands not represented in the regional model are represented as drains in the subregional model. These included all features on the National Wetlands Inventory designated as permanently flooded, excavated wetlands. These features were assigned a drain elevation of six feet below land

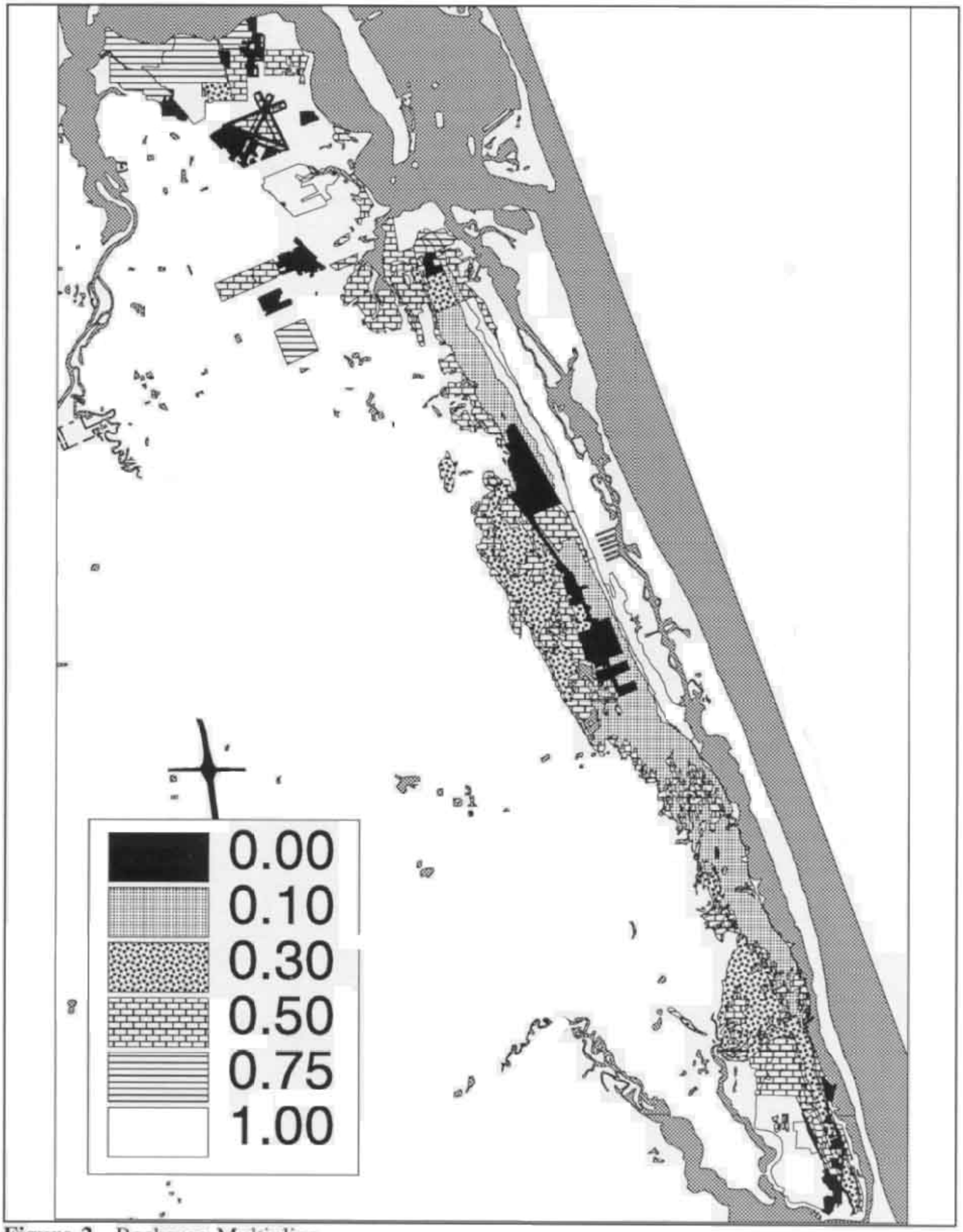


Figure 2. Recharge Multiplier

surface.

Calibration Results

Monthly water-levels were available from 73 observation wells for at least some portion of the period from January 1989 to December 1990. As previously stated, the objective of this project was to produce, with minimum alteration, a high resolution model that worked as well or better than the regional model from which it was created. This condition was tested by comparing the average difference between observed and predicted water-levels for each model (Table 1), and visual evaluation of the pattern match between simulated and observed hydrographs (Appendix A).

The subregional model was considered to meet the quantitative test if, on average, the predicted head at a well fell within one foot of the observed head, or if the head difference was as close or closer than that of the regional model. This criteria was met at 90 percent (66 out of 73) of the observation wells. Figures 3-7 shows the location of each observation well, and the quality of the models response at that location.

Of the seven recalcitrant wells, five (M-1024, M-1028, M-l 183, PB-746 and TQT7R1) are in proximity to public water supply wells (Stuart and Tequesta). The water levels predicted by the subregional model are all lower than observed at these locations. It was noted during sensitivity analysis that if public water supply demands were shut off, the modeled water levels were much closer to observed. The modeled demands from these wellfields were collected by Adams (1992) as total monthly withdrawals based on flow meters (Tequesta) or pump capacity times reported hours of operation (Stuart). As such, it is expected that the withdrawals represented by the model are fairly accurate. It is suspected that the problem lies in the time discretization of the modeling. The model takes the total monthly withdrawal and represents it as a continuous daily withdrawal for that month. Water level readings from the observation wells were taken as a point in time, usually towards the end of the month. Judging by the way the water levels rebound when the wells are turned off, it is suspected that the actual pumping at those wells was concentrated at the beginning of the month, so that the water levels had time to rebound before the observation was recorded. Another well, M- 1141, that meets the difference criteria but displays a poor pattern match is believed to suffer from the same problem.

Table 1. Average Difference Between Observed and Modeled Heads for the Regional and Subregional models over the Calibration Period.

Layer	Row	Column	Well	Difference [ft]	
				Regional	Subregional
2	75	84	HY2	Missing	0.9
3	75	82	HY2R	0.6	0.5
2	75	83	HY3	Missing	0.7
3	75	82	HY3R	0.4	0.4
2	40	45	ICU2	Missing	0.7
2	157	114	JHSW1	2.0	1.8
2	165	117	JHSW3	0.4	0.3
2	16	36	M-1010	2.0	1.5
2	8	22	M-1011	1.3	1.1
2	170	118	M-1024	0.6	1.2
2	171	119	M-1028	0.9	1.2
2	170	118	M-1039	0.4	0.6
2	110	95	M-1044	1.5	1.4
2	50	53	M-1052	3.2	1.0
2	26	37	M-1055	2.7	0.6
2	81	81	M-1057	3.7	0.5
2	148	111	M-1070	0.5	0.5

2	150	106	M-1071	1.4	1.2
1	150	106	M-1072	1.3	1.0
2	135	100	M-1073	0.3	0.7
3	12	15	M-1090	1.7	0.5
2	13	26	M-1091	3.6	1.9
2	112	97	M-1092	1.9	2.1
2	145	104	M-1093	0.5	1.1
2	154	107	M-1094	0.7	0.7
2	142	109	M-1095	0.6	0.9
2	27	42	M-1132	0.6	0.3
2	31	26	M-1141	3.6	3.4
2	33	14	M-1146	2.8	1.1
2	33	14	M-1147	2.4	1.6
2	6	22	M-1158	1.7	0.6
2	16	36	M-1161	2.5	0.5
2	26	39	M-1165	1.1	0.6
1	28	20	M-1179	3.8	1.1
1	31	26	M-1183	2.8	4.5
3	166	79	M-1229	0.5	0.9
3	161	98	M-1230	0.7	0.4
2	182	22	M-1231	1.2	0.9
1	166	79	M-1232	0.8	0.7
1	161	98	M-1233	0.5	0.8
3	119	26	M-1235	2.9	2.0
2	62	24	M-1253	1.7	1.0
1	62	24	M-1257	1.2	1.2
1	110	95	M-1258	0.5	0.5
2	119	70	M-1259	0.5	0.7

1	74	67	M-1269	2.1	0.8
1	119	26	M-1270	1.3	0.8
2	13	22	M-147	2.3	1.7
2	43	64	MGD-1	0.8	0.5
2	42	63	MGD-2	0.8	0.3
2	41	62	MGD-3	Missing	0.3
2	42	57	MGD-4	2.5	0.7
2	48	53	MGD-5	1.1	0.6
1	41	61	MGS-02	1.2	0.8
1	43	54	MGS-03	0.7	0.4
1	45	56	MGS-05	1.0	0.9
1	46	57	MGS-06	1.9	0.6
1	45	59	MGS-07	1.2	0.9
1	44	62	MGS-08	0.8	0.7
1	44	61	MGS-10	1.1	0.9
2	175	118	PB-595	0.4	0.4
2	183	115	PB-720	1.3	0.6
2	181	112	PB-721	0.9	0.4
2	178	112	PB-722	0.9	0.4
2	174	118	PB-746	1.2	1.4
2	174	115	PB-890	3.1	1.8
2	181	112	PB-892	1.0	0.5
2	180	119	PB-932	1.4	1.2
2	179	118	TQD13	0.6	1.0
2	169	118	TQD35	Missing	1.0
2	173	113	TQT231	1.4	1.2
2	180	116	TQT7R1	1.7	2.2

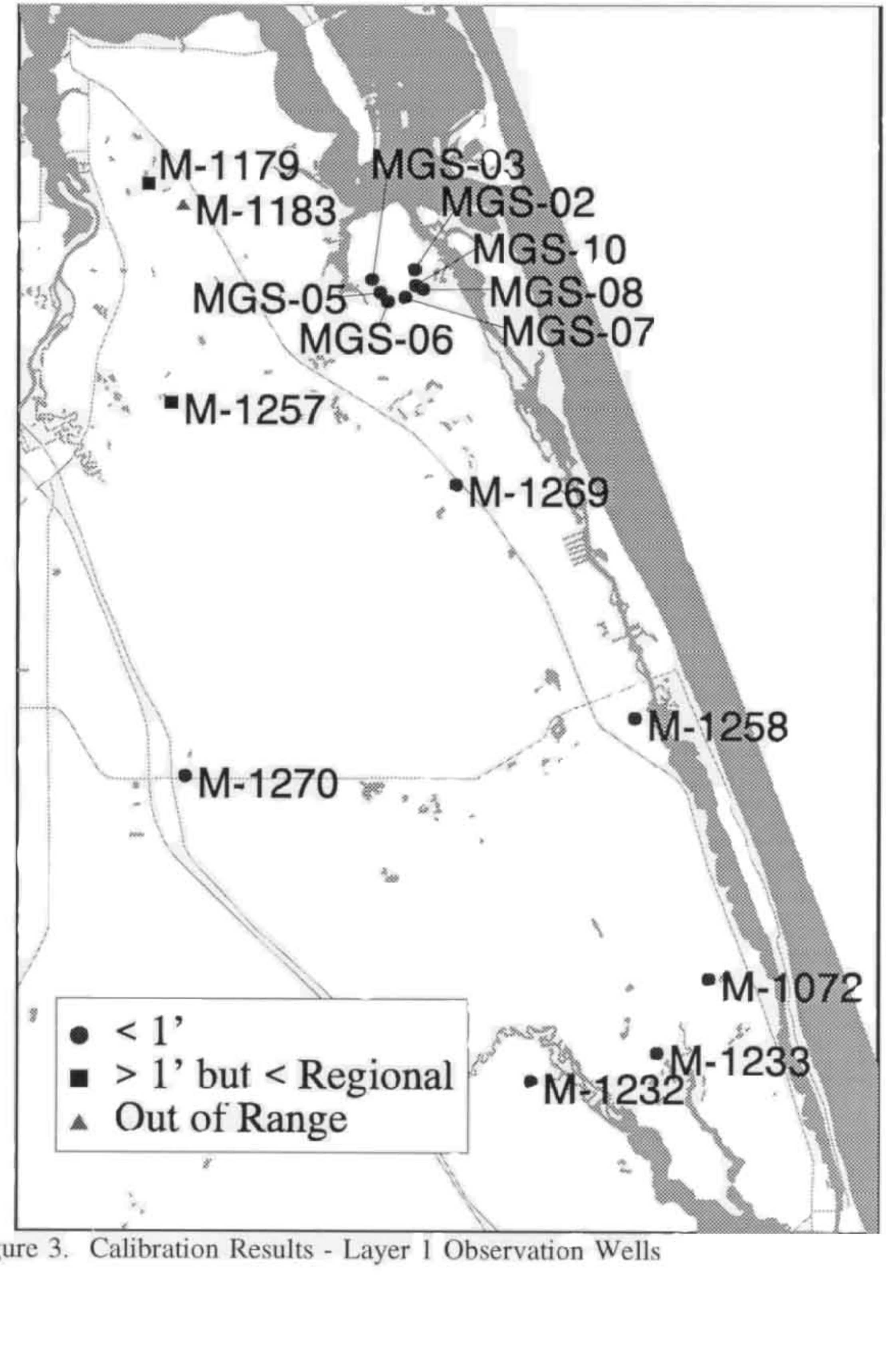


Figure 3. Calibration Results - Layer 1 Observation Wells

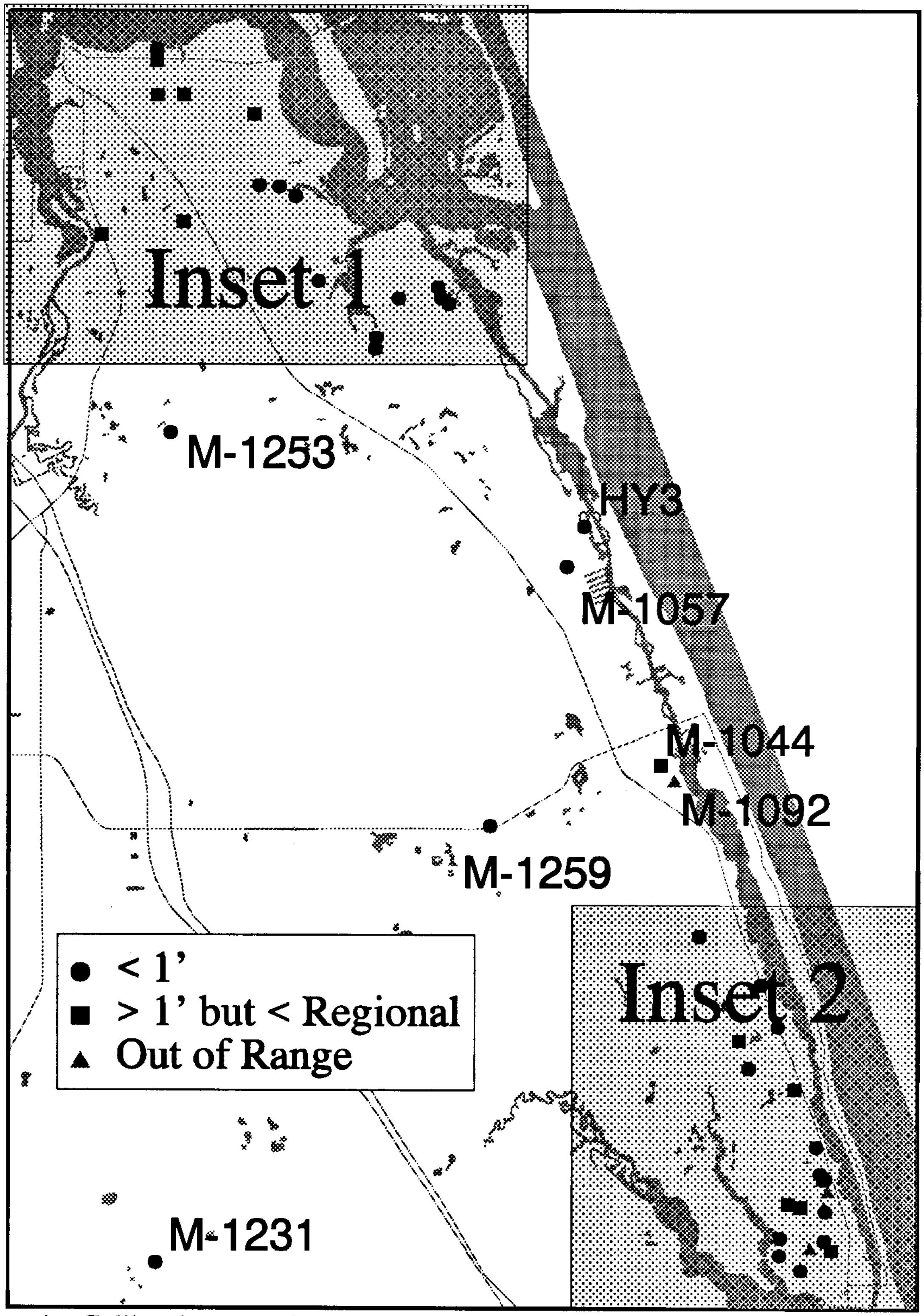


Figure 4. Calibration Results - Layer 2 Observation Wells

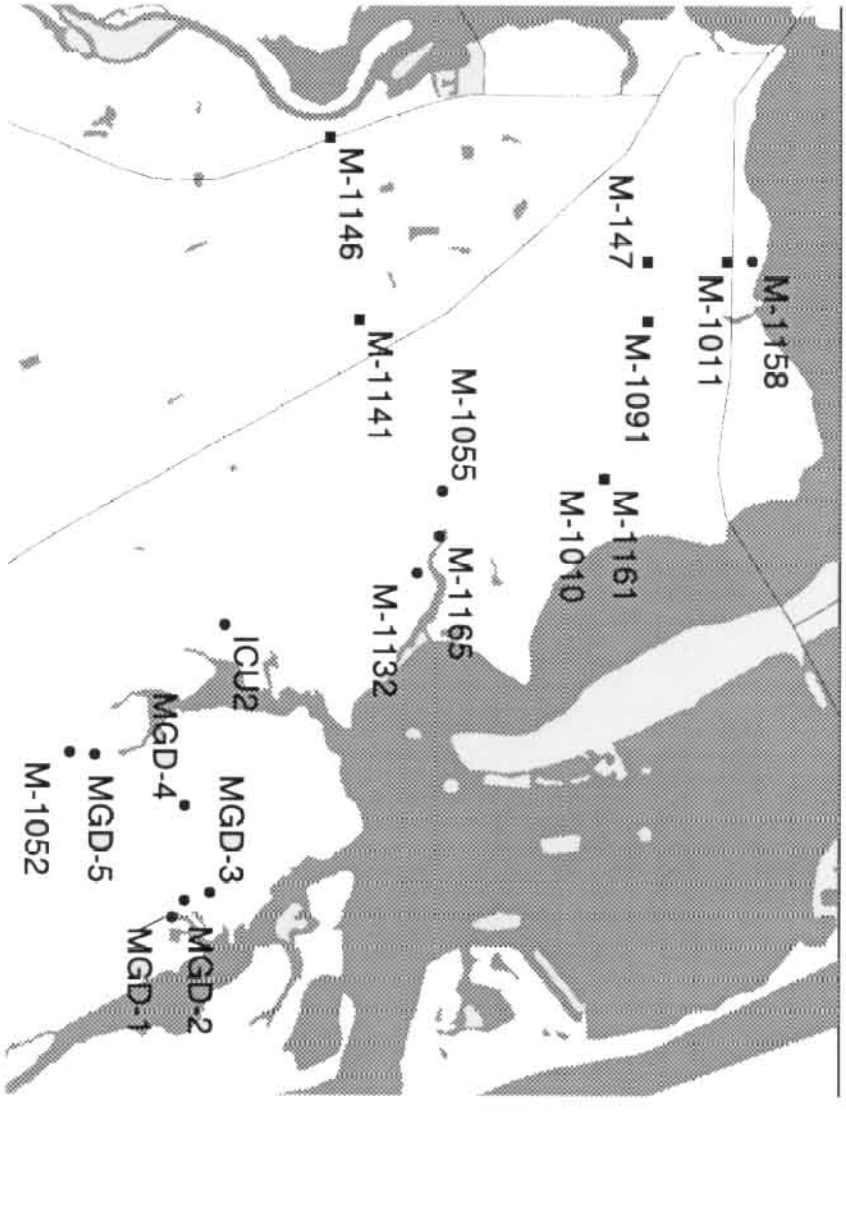


Figure 5. Layer 2 - Inset 1

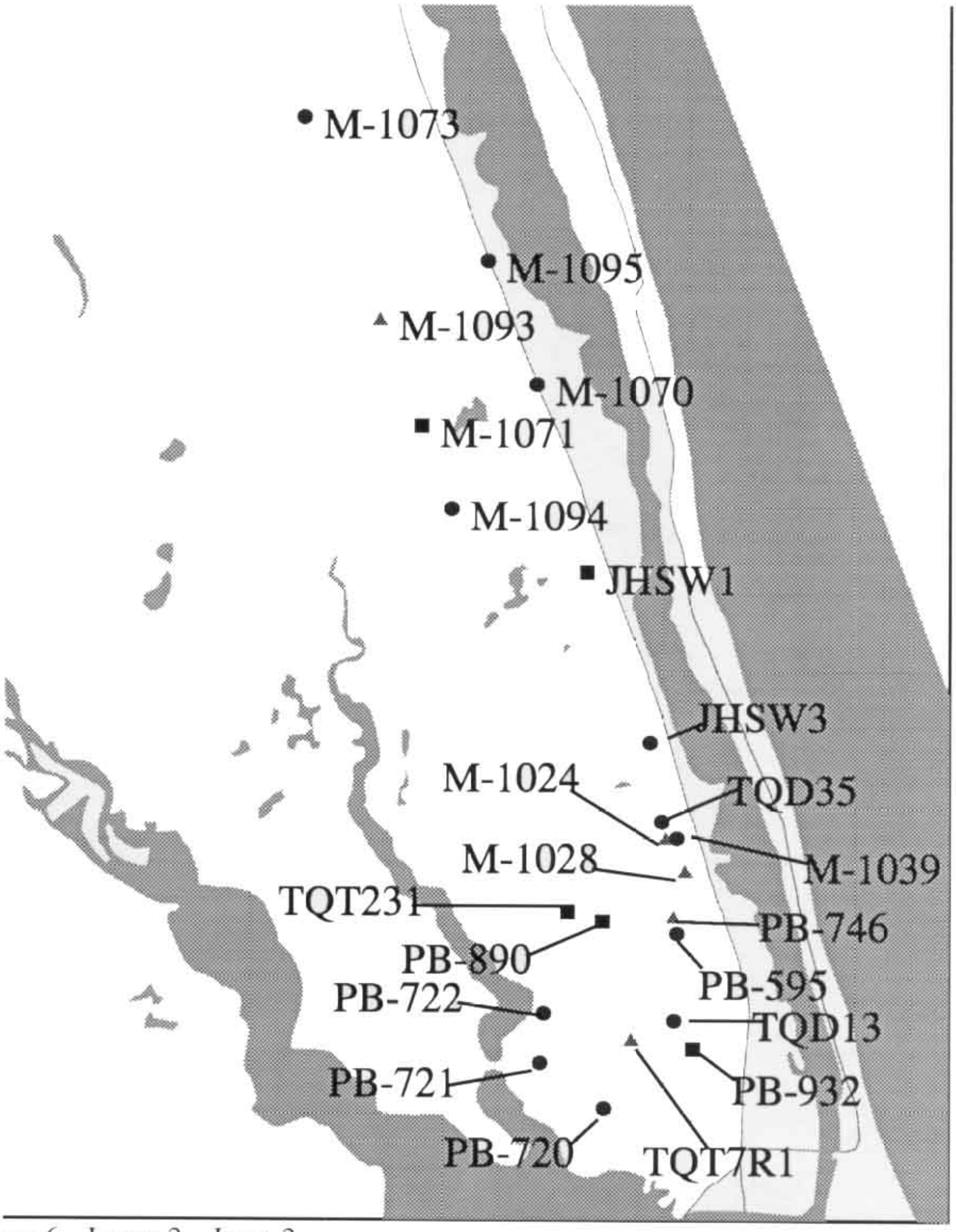


Figure 6. Layer 2 - Inset 2

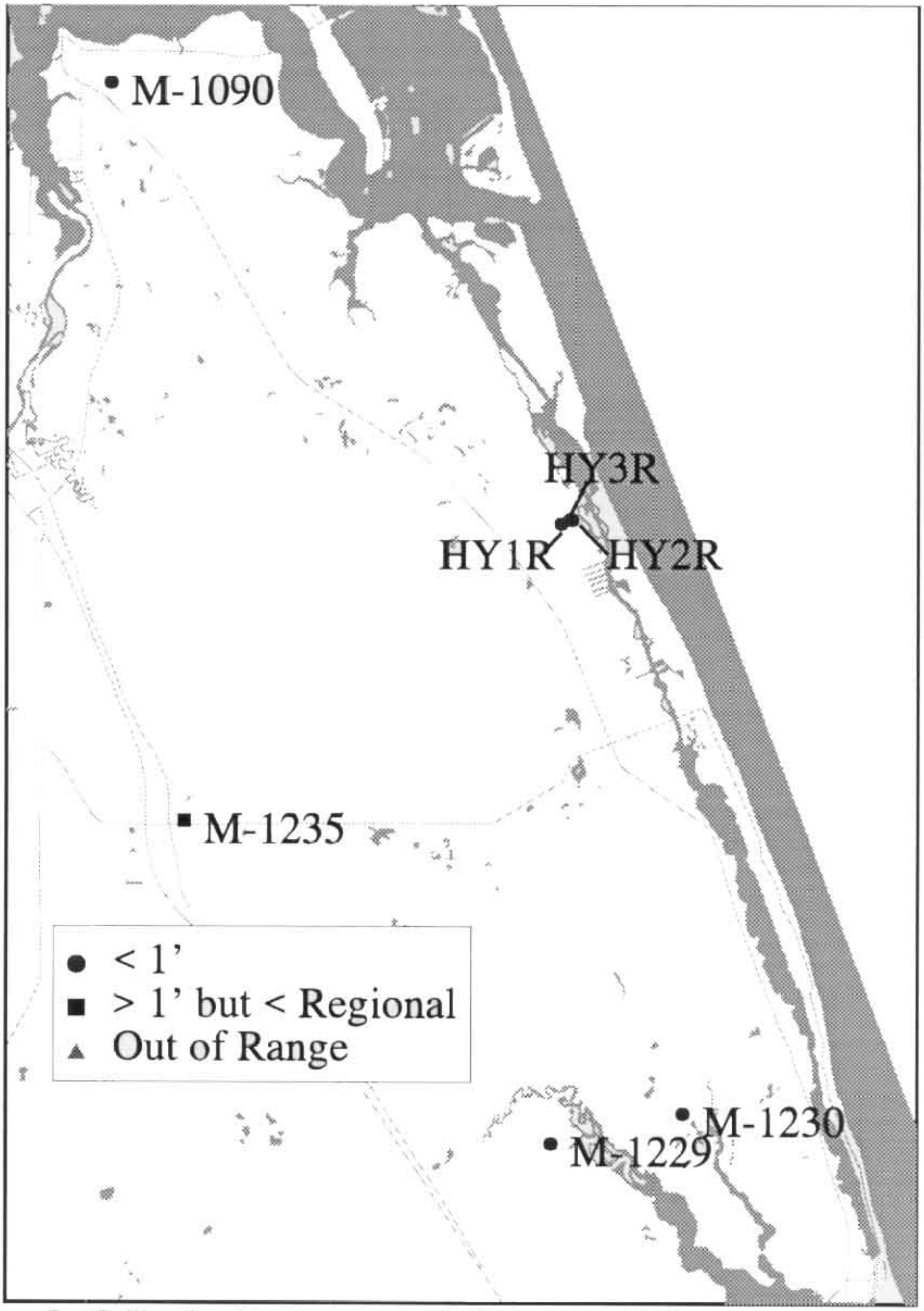


Figure 7. Calibration Results - Layer 3 Observation Wells

References

Adams, Karin, ***A three-dimensional finite difference flow model of the surjicial aquifer in Martin county, Florida.*** South Florida Water Management District Technical Publication 92-02, 220 pp., 1992

Lukasiewicz, J, and K. A. Smith, ***Hydrogeologic data and information collected from the surficial and Floridan aquifer systems, Upper East Coast planning area. South*** Florida Water Management District Technical Publication 96-02, 224 pp., 1996